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THE EFFECT OF INCREASING NITROGEN FERTILIZER RATES ON SEEDLING GROWTH AND POST PLANTING SURVIVAL AND GROWTH

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ABSTRACT

In this nitrogen, phosphorus and potassium trial, levels of elemental nitrogen ranging from 0 to 269 kg/ha for white pine (Pinus strobus L.) and 0 to 168 kg/ha for red pine (Pinus resinosa Ait.) and white spruce (Picea glauca [Moench.] Voss.) in the 2+0 year and 0 to 358 and 0 to 224 kg/ha respectively in the 3+0 year did effect the size of the final 3+0 seedlings, for all parameters measured except T/R ratio. The phosphorus and potassium additions when added to the nitrogen applications did not affect growth when compared to similar levels of nitrogen applied alone.

Survival, after out planting, was not affected by fertilizer treatment, although first year height growth of the white spruce did show a positive response to to increasing levels of nitrogen.

INTRODUCTION

For many years Ontario nurseries have been using fertilizers, both for soil amendments and top dressings, as a means of influencing the development of tree seedlings, (Armson and Sadreika, 1979). At Orono nursery, over the past twenty years, following these directives has resulted in the seedlings increasing in size to the point where a few species, particularily red pine and white spruce, are considered, by some, to be too large to make good planting stock. The tests described in this paper were designed to see how, by manipulating the amount of nitrogen applied during the top dressing programmes, we could alter the final seedling size. We also planned to investigate whether potassium and phosphorus would be limiting to growth, in Orono soils, which now have fairly high levels of both these elements (P - 25 to 30 mg/100g and K - 0.25 to 0.30 meq/100g).

As well we planned to see if post planting survival and growth would be affected by the treatments. McLain (1982) had found for white spruce, but not for black spruce (Picea mariana [Mill.] BSP), that increasing levels of nitrogen fertilizer were detrimental to both survival and growth after outplanting

AIM

The aim of the programme was then threefold:

1. To observe the effect, on developing seedlings, of increasing amounts of nitrogen fertilizer.

2. To find out if phosphorus and potassium would be limiting to growth, in Orono soils, as nitrogen fertilizer levels were

increased.

3. To observe the effect which different rates of fertilizer might have on out-planting survival and growth.

METHODS

The test was of random plot design with four replications and eight treatments.

1. 0N - Control, no fertilizer applied.
2. 0N+PK - No nitrogen but phosphorus and potassium added.
3. .5N - one half Orono's normal nitrogen addition.
4. .5N+PK - one half normal nitrogen plus phosporus and potassium.
5. N - Normal nitrogen addition.
6. N+PK - Normal nitrogen plus phosporus and potassium.
7. 2N - Twice normal nitrogen addition.
8. 2N+PK - Twice normal nitrogen plus phosporus and potassium.

Three species were treated, white pine, red pine and white spruce. Fertilizer applications were made during the 2+0 and 3+0 years of production. The nitrogen fertilizer used was ammonium sulphate and normal application rates were 84 kg/ha in 2+0 and 112 kg/ha in the 3+0 year. The white pine received eight applications of ammonium sulphate in both the 2+0 and 3+0 years, while the red pine and white spruce received five. (Table 1 & 2). Potassium was applied as potassium sulphate at 56kg/ha in the 2+0 year and 112kg/ha in the 3+0 year. Two applications were made in each season on May 10th and July 4th (Table 1 & 2). Phosphorus was applied as phosphoric acid dissolved in water and applied to the plots with a watering can. Two applications were made at 93kg/ha on June 1st and August 1st in both the 2+0 and 3+0 years (Table 1 & 2).

The nutrient levels of the compartments used in this trial, T-74 for white pine, S-01 for red pine and S-34 for white spruce, were at or close to what, we at Orono, consider to be *optimum* growing conditions: Ph 5.5 TO 6.5; Organic Carbon 2% to 3%; Phosphorus 30mg/100g; potassium 0.3 meq/100g and magnesium 0.4 to 0.5 meq/100g (Table 4).

Seedlings were sampled at the end of the 3+0 season to assess the effects of the various treatments on the morphology of the stock (Table 3).

The white spruce treatments were lifted the first week of November 1982, packed in multiwalled paper bags with a 2 mil poly liner and placed in frozen storage at -2 to -4°C until shortly after the first of April 1983 when the storage temperature was raised to +1 to +2°C. The red pine and white pine treatments were lifted on April 12th and 13th, packed in multiwalled kraft bags with a 2 mil poly liner and place in cool storage at +1 to +2°C. All species were planted on the Banaraska

Forest, about 16 km north and east of Orono, on April 19th 1983. The weather was cool, snow overnight, and cloudy.

At the time of lifting the 8N, 8N+PK, .5N and .5N+PK treatments of white spruce were yellowish-green in colour. We attributed this to nitrogen deficiency. The 2N but not the 2N+PK treatment, in red pine, showed orangish-yellow tipping of the needles which we attributed to a potassium deficiency. The white pine did not exhibit any visual signs of nutrient deficiency.

RESULTS

The increasing levels of nitrogen did produce significantly larger measurements for Root Collar Diameter (RCD) and Total Dry Weight (TDW) for all species (Table 3). The treaments also produced significant differences in Root Area Index (RAI) for white pine and white spruce and Height (HT) for red pine and white spruce. The Top/Root (T/R) ratios for all species were unaffected by treatment. The addition of phosphorus and potassium to the various nitrogen applications did not significantly increase the growth of that treatment (Table 3), when compared to the same level of nitrogen applied alone.
Soil moisture conditions after field planting, were very favourable for seedling establishment, remaining close to field capacity until the end of May, as calculated according to Thornthwaite (1948) (Figure 1). Observation of the planting site showed that by the latter part of May most of the seedlings had broken bud and had begun to grow. During June soil moisture was rapidly depleted, as we experienced a prolonged period without rain, and drought conditions were entered into before the end of the month. These drought conditions continued through July, August and the first half of September, with only brief respites. As a result, seedlings which had flushed and begun to grow in May and early June were beginning to die by the end of June.

Since we feel that had we experienced a season with normal rainfall, rather than an extremely dry season, most of the seedlings which were flushed and growing in May and early June would have survived the summer, we are reporting two sets of survival data. The first set shows those seedlings which flushed and began to grow. The second set shows those seedlings which were able to survive and grow to the end of the summer. These data show that there were no significant differences, for either the flushed or surviving seedlings, due to fertilizer treatment (Table 5).

The current years growth, the growth produced in 1983, did not show any significant response to the level of the fertilizer treatment applied for white pine or red pine (Table 6). White spruce, on the other hand, did show a positive growth response to increasing levels of nitrogen.

DISCUSSION

It is interesting, to us, that the addition of phosphorus and potassium to the various levels of nitrogen applied, did not affect the growth response of that treatment, either on the nursery or after out planting. This has been our observation

over the years, as far as growth at Orono is concerned.

At the start of intensive soil management, at Orono, some twenty years ago , when soil phosphorus levels were in the 10 to 15mg/100g range, we found it necessary to add phosphorus along with nitrogen in order to maximize seedling growth. Potassium did not seem to affect growth, but rather appeared to be involved in lignification and the setting of healthy buds.

Over the years, as the phosphorus level, of the Orono soils, was increased, approaching the 25mg/100gm to 30mg/100g level, we found that it became unnecessary to add phosphorus, along with nitrogen, to maximize growth. This trial was the first to formally test this hypothesis and has seemingly proved the correctness of our observations.

While potassium and phosphorus did not affect seedling growth in this trial, these results may only be valid, at other places, where the soil levels, of these nutrients, approach the values of these Orono compartments. Armson and Sadreika (1979), page 44 to 46, show a growth response to the addition of phosphorus in a nitrogen, phosphorus and potassium trial at Swastika nursery. While the levels of soil phosphorus are not given, since the Swastika nursery, at that time, was a relatively new nursery, we think it is safe to assume that the phosphorus levels were relatively low.

The lack of a detrimental affect on either the survival or growth after out planting would seem to indicate, that for these species at least, it is safe to apply varying amounts of nitrogen fertilizer, up to the amount used in this trial, in order to manipulate the final seedling size.

All parameters measured, except T/R, showed a positive response to the increasing levels of nitrogen applied, although not always significantly so. When comparing the 3+0 sizes obtained in this trial with the classes of stock as outlined by Reese and Sadreika (1979), (Table 7) we find for RCD and TDW that for white pine The RCD varied from very large to medium and the TDW from very large to large. For red pine RCD ranged from very large to large and TDW from very large to medium. For white spruce the RCD ranged from very large to small and the TDW from very large to cull.

Obviously, if one wishes to be able to grow white pine and red pine, ranging in size from large to small, then he is going to have to depend on a factor to be used in conjunction with fertilizer manipulation to accomplish this. Root pruning and root pruning and wrenching, Bunting and McLeod (1984a&b) might be utilized. Irrigation control, where soil moisture is allowed to drop low enough to reduce growth, is another function that comes to mind, although we feel that if this method is to be used, then to prevent a possible disaster, an accurate method of measuring soil moisture must be available.

For white spruce, according to these data, the manipulation of fertilizer amounts, alone, will allow for the production of

seedlings from large to small. As mentioned before, the 0N, 0N+PK, .5N and .5N+PK treatments resulted in the white spruce seedlings exhibiting signs of nitrogen deficiency. While these seedlings did not show any significant reduction in survival, after out planting, they did show a reduction in growth at the end of the first season. For this reason we feel that seedlings showing signs of nitrogen deficiency should not be shipped. Once again one might have to use root pruning or irrigation withdrawal, in conjunction with fertility control to produce a small class of healthy looking white spruce seedlings.

We feel that the questions asked in the aims of this trial have been answered. These data show:

1. That growth, on the nursery, of white pine, red pine and white spruce shows a positive response to increasing amounts of nitrogen fertilizer, up to the amounts used in this trial;

2. In Orono soils, phosporus and potassium are not limiting as increasing amounts of nitrogen are used, up to the double Orono's normal application;

3. Survival after field planting, is not affected by the amount of nitrogen top dressing applied, within the limits used in this trial. Growth, after planting, is not affected for white pine and red pine but shows a positive response to increasing amounts of nitrogen, for white spruce.

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TABLE 1

FERTILIZER APPLICATIONS

Species	Treatment	Elemental N per Applic't'n kg/ha	No. Times Applied	Total El. N Applied kg/ha
		Applied During 2+0 Year		
White Pine	0N	0	8	0
	.5N	8.4	8	67.2
	N	16.8	8	134.4
	2N	33.6	8	268.8
Red Pine & White Spruce	0N	0	5	0
	.5N	8.4	5	42.0
	N	16.8	5	84.0
	2N	33.6	5	168.0
All Species	+P	22.4	2	44.8
	+k	22.8	2	45.6
		Applied During 3+0 Year		
White Pine	0N	0	8	0
	.5N	11.2	8	89.2
	N	22.4	8	179.2
	2N	44.8	8	358.4
Red Pine & White Spruce	0N	0	5	0
	.5N	11.2	5	56.0
	N	22.4	5	112.0
	2N	44.8	5	224.0
All Species	+P	22.4	2	44.8
	+K	45.6	2	91.2

TABLE 2

FERTILIZER APPLICATION DATES

2+0 Dates

Ammonium Sulphate at 84 kg/ha

White Pine	Red Pine & White Spruce
1. May 10	1. May 10
2. May 30	2. June 13
3. June 13	3. July 15
4. July 4	4. Aug. 15
5. July 25	5. Sept. 19
6. Aug. 15	
7. Sept. 5	
8. Sept. 19	

Potassium Sulphate at 56 kg/ha

1. May 10	1. May 10
2. July 4	2. July 4

Phosphoric Acid at 93 kg/ha

1. June 1	1. June 1
2. Aug. 1	2. Aug. 1

3+0 Dates

Ammonium Sulphate at 112 kg/ha

1. May 10	1. May 10
2. May 30	2. June 13
3. June 13	3. July 15
4. July 4	4. Aug. 15
5. July 15	
6. Aug. 15	
7. Sept. 19	
8. Oct. 10	

Potassium Sulphate at 112 kg/ha

1. May 10	1. May 10
2. July 4	2. July 4

Phosphoric Acid at 93 kg/ha

1. June 1	1. June 1
2. Aug. 1	2. Aug. 1

TABLE 3

3+0 SEEDLING SIZES

White Pine

Treatment	RCD mm	TDW g	HT cm	RAI cm^2	T/R
2N+PK	5.12ab	8.92ab	21.25	81.86a	2.40
2N	5.35a	9.58a	23.25	76.93ab	2.62
N+PK	5.11ab	8.80ab	23.40	69.19abc	2.70
N	4.85ab	7.46 bc	22.27	69.04abc	2.46
.5N+PK	4.73 bc	8.13ab	24.25	66.36abcd	3.00
.5N	4.54 bcd	7.49 bc	23.47	61.44 bcd	2.81
0N+PK	4.07 d	6.41 c	21.07	47.75 cd	3.22
0N	4.26 cd	6.51 c	20.69	55.84 d	2.83
	**	**	NS	*	NS

Red Pine

2N+PK	6.14a	14.31a	37.37a	51.89	7.15
2N	5.93a	13.35a	36.86ab	55.11	6.83
N+PK	5.66ab	12.04ab	34.30 bc	44.14	6.91
N	5.68ab	11.33abc	32.95 c	45.61	6.66
.5N+PK	5.00 bc	9.32 bc	29.32 d	39.48	6.72
.5N	5.02 bc	9.49 bc	31.40 cd	42.91	6.35
0N+PK	4.93 c	8.93 bc	29.62 d	41.76	6.14
0N	4.85 c	8.31 c	29.41 d	39.55	6.64
	**	*	***	NS	NS

White Spruce

2N+PK	5.30a	7.43a	31.56a	46.58a	3.01
2N	5.29a	6.94ab	30.12ab	47.57a	3.04
N+PK	4.83 b	5.98abc	29.12 b	40.95abc	3.12
N	4.81 b	6.06abc	28.84 b	43.28ab	2.85
.5N+PK	4.37 c	5.12 cd	24.22 c	45.52ab	2.78
.5N	4.07 c	4.44 cd	24.89 c	36.46 bcd	3.09
0N+PK	3.63 d	3.42 e	20.98 d	32.07 cd	2.99
0N	3.60 d	3.00 e	20.61 d	30.60 d	2.99
	***	***	***	**	NS

NS - No significant differences.
* - Significant differences at 5% level.
** - Significant differences at 1% level.
*** - Significant differences at 0.1% level.
Figures followed by the same letter do not vary significantly at the 5% level.

TABLE 4

COMPARTMENT FERTILITY LEVELS

	White Pine T-74	Red Pine S-01	White spruce S-34
pH	5.8	5.3	6.5
Organic C.	2.25%	1.93%	1.97%
Phosphorus	20.33mg/100g	31.20mg/100g	28.26mg/100g
Potassium	0.20meq/100g	0.26meq/100g	0.26meq/100g
Magnesium	0.35meq/100g	0.56meq/100g	0.37meq/100g

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TABLE 5

FIRST YEAR POST PLANTING
PERCENT SURVIVAL

Treatment	White Pine	Red Pine	White Spruce
	Trees which flushed and grew		
2N+PK	100.0	93.6	85.0
2N	100.0	95.7	91.4
N+PK	99.2	97.2	87.1
N	97.8	96.5	86.4
.5N+PK	98.5	100.0	87.1
.5N	99.2	95.8	81.4
0N+PK	99.2	96.5	75.0
0N	100.0	98.6	80.7
	NS	NS	NS
	Trees surviving at end of season		
2N+PK	44.3	17.2	5.7
2N	45.7	21.3	10.7
N+PK	43.8	21.3	15.7
N	49.6	28.6	12.9
.5N+PK	43.6	35.6	6.4
.5N	38.2	30.6	5.7
0N+PK	52.6	22.8	15.0
0N	57.1	30.0	15.0
	NS	NS	NS

NS - No significant differences.

TABLE 6

FIRST YEAR POST PLANTING
CURRENT HEIGHT GROWTH
cm

Treatment	White Pine	Red Pine	White Spruce
2N+PK	10.69	5.69	5.40a
2N	9.77	7.16	5.29a
N+PK	10.18	5.88	4.71ab
N	9.42	5.60	5.06ab
.5N+PK	10.06	5.96	3.02 d
.5N	9.95	5.82	4.16 b
0N+PK	8.94	5.98	3.05 cd
0N	10.02	6.10	4.08 bc
	NS	NS	***

NS - No significant differences.
*** - Significant differences at 0.1% level.
Figures followed by the same letter do not vary at the 5% level.

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TABLE 7

3+0 RCD AND TDW
RATED BY ONTARIO'S
SIZE CLASS STANDARDS

Treatment	White Pine		Red Pine		White Spruce	
	RCD	TDW	RCD	TDW	RCD	TDW
2N+PK	VL	VL	VL	VL	VL	VL
2N	VL	VL	VL	VL	VL	L
N+PK	VL	VL	VL	VL	L	M
N	L	VL	VL	VL	L	M
.5N+PK	L	VL	L	L	M	M
.5N	L	VL	L	L	S	S
0N+PK	M	L	L	M	S	S
0N	M	M	L	M	S	CULL

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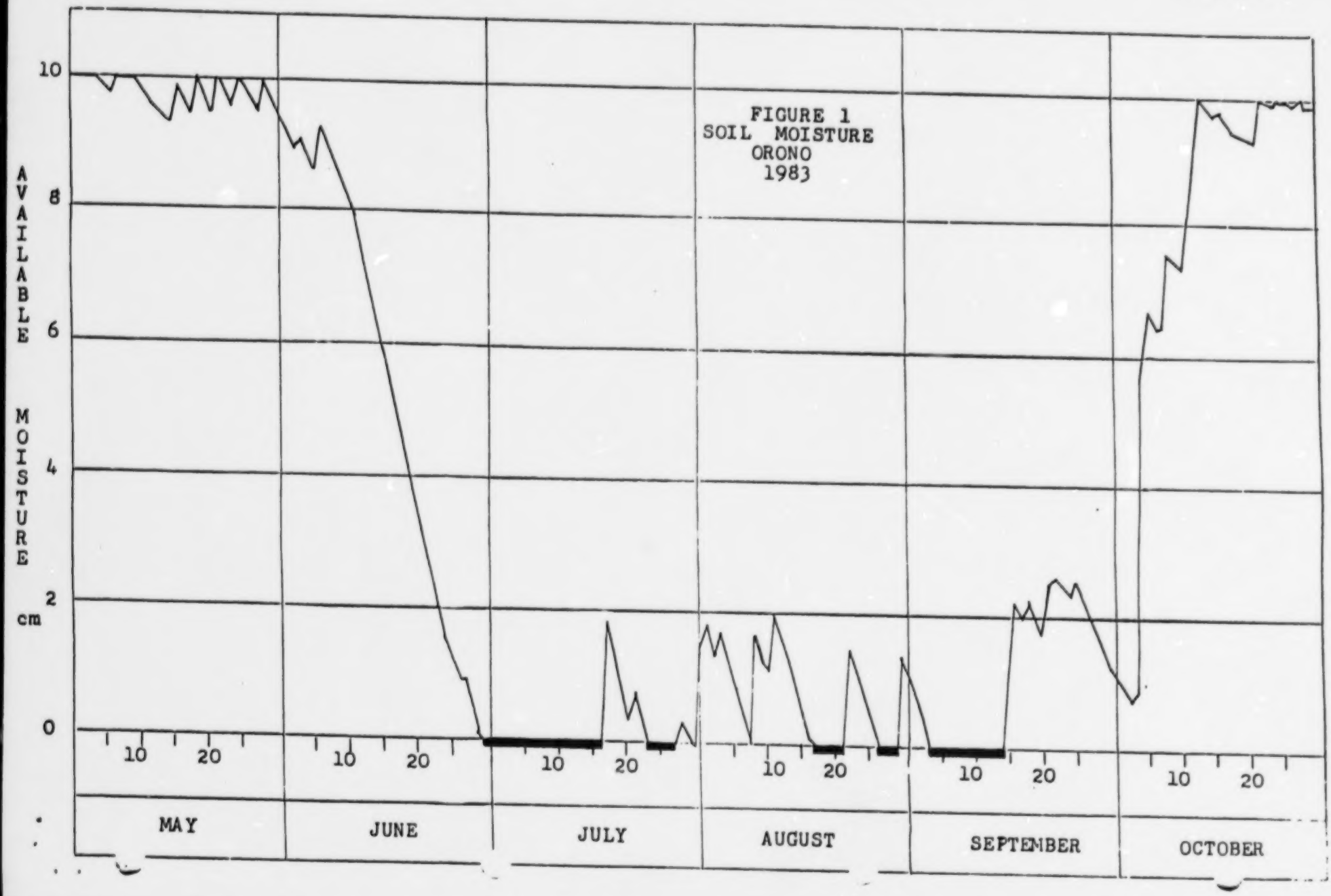
FIGURE 1
SOIL MOISTURE
ORONO
1983
AVAILABLE MOISTURE cm
10
8
6
4
2
0
10
20
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER